

# **AIR FORCE QUALIFICATION TRAINING PACKAGE (AFQTP)**



for  
ELECTRICAL POWER PRODUCTION  
(3E0X2)

## **MODULE 22 ALTERNATORS, EXCITERS, AND ELECTRIC MOTOR GENERATORS**

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Career Field Education and Training Plan (CFETP) References from 1 May 97 version

OPR: HQ AFCESA/CEOF  
(SMSgt Mike Trevino)

Certified by: HQ AFCESA/CEO  
(Colonel Lance C. Brendel)

**Notice.** This AFQTP is NOT intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

**AIR FORCE QUALIFICATION TRAINING PACKAGES**  
**for**  
**ELECTRICAL POWER PRODUCTION**  
**(3E0X2)**

**INTRODUCTION**

***Before starting this AFQTP, refer to and read the “Trainee/Trainer Guide” located on the AFCESA Web site <http://www.afcesa.af.mil/>***

***AFQTPs are mandatory and must be completed*** to fulfill task knowledge requirements on core and diamond tasks for upgrade training. ***It is important for the trainer and trainee to understand*** that an AFQTP ***does not*** replace hands-on training, nor will completion of an AFQTP meet the requirement for core task certification. AFQTPs will be used in conjunction with applicable technical references and hands-on training.

***AFQTPs and Certification and Testing (CerTest) must be used as minimum upgrade requirements for Diamond tasks.***

**MANDATORY minimum upgrade requirements:**

***Core task:***

AFQTP completion  
Hands-on certification

***Diamond task:***

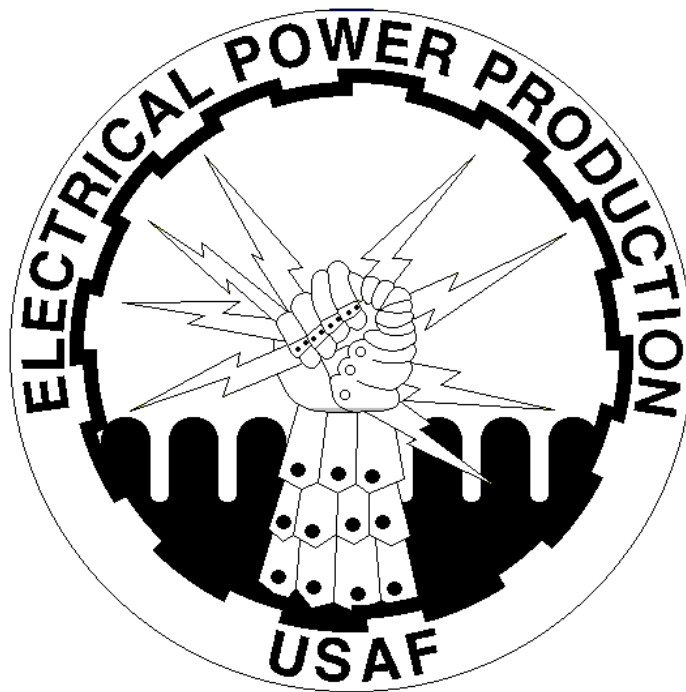
AFQTP completion  
CerTest completion (80% minimum to pass)

***Note: Trainees will receive hands-on certification training for Diamond Tasks when equipment becomes available either at home station or at a TDY location.***

***Put this package to use.*** Subject matter experts under the direction and guidance of HQ AFCESA/CEOF revised this AFQTP. If you have any recommendations for improving this document, please contact the Career Field Manager at the address below.

HQ AFCESA/CEOF  
139 Barnes Dr. Suite 1  
Tyndall AFB, FL 32403-5319  
DSN: 523-6392, Comm: (850) 283-6392  
Fax: DSN 523-6488  
E-mail: [ceof.helpdesk@tyndall.af.mil](mailto:ceof.helpdesk@tyndall.af.mil)

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## **ALTERNATORS, EXCITERS, AND ELECTRIC MOTOR GENERATORS**

**MODULE 22**

**AFQTP UNIT 4**

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### **FLASH EXCITER FIELDS (22.4.)**

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## FLASH EXCITER FIELDS

### *Task Training Guide*

<b>CFETP Reference Number:</b>	22.4., Flash Exciter Fields
<b>Training References:</b>	<ul style="list-style-type: none"> <li>• 35C2 series Technical Order</li> <li>• Manufacturer's Manual</li> <li>• Local Procedures</li> </ul>
<b>Prerequisites</b>	<ul style="list-style-type: none"> <li>• Possess as a minimum a, 3E032 AFSC</li> </ul>
<b>Equipment/Tools Required:</b>	<ul style="list-style-type: none"> <li>• Hearing protection</li> <li>• Eye protection</li> <li>• Multimeter</li> </ul>
<b>Learning Objective:</b>	<ul style="list-style-type: none"> <li>• Demonstrate principles and purpose for flashing the exciter field on MEP generator sets.</li> <li>• Safely isolate and repair probable malfunctions</li> </ul>
<b>Samples of Behavior:</b>	<ul style="list-style-type: none"> <li>• Trainee should successfully flash the exciter field on MEP generators.</li> </ul>
<b>Notes:</b>	
<ul style="list-style-type: none"> <li>• Any safety violation is an automatic failure.</li> </ul>	

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## FLASH EXCITER FIELDS

**Background:** Older style generators, such as the MB-Teen series, relied upon residual magnetism of the generator pole pieces to produce a small initial voltage that increases as the generator comes up to speed. For this reason, the exciter field pole must retain residual magnetism for the generator to produce the initial voltage. If residual magnetism is lost, it must be restored. This is accomplished by sending direct current through the field windings of the exciter in a direction to establish the proper polarity, normally while the unit is running. If the exciter has not been operated for a period of time, you may need to flash the exciter field to regain the residual magnetism.

On the newer style generators, such as the MEP series generators, the generator has a built in field flashing circuit for the exciter. This means that the technician will not need to worry about the exciter losing its residual magnetism. If the generator does not build up voltage after it has been started, the field flashing circuit needs to be troubleshot. A technician should **never** hook-up a battery directly to the exciter in order to flash the exciter field.

**Field Flashing:** On a MEP (MEP 4,5,6,7,9) generator, the field is flashed through the contacts of the K5 relay (Figure 1). Sometimes the generator voltage will not build up after being started. This may be due to either the field not getting flashed properly or the generator operator did not hold the Run-Start-Stop switch up long enough to flash the field. In either case use the following procedures below to re-flash the generators exciter field.

**SAFETY:**

**PERFORM ALL PREOPERATIONAL INSPECTIONS AND WEAR PROPER SAFETY EQUIPMENT WHILE THE GENERATOR IS IN OPERATION.**

**Procedures for Re-flashing generator exciter (MEP 4,5,6,7,9 generators).**

- Complete Pre-operation inspection according to T.O.
- Close D.C. circuit breaker.
- Hold the Start-Run-Stop switch to the run position until the engine oil pressure gauge indicates oil pressure, and voltmeter indicates voltage.
- If the voltmeter ***DID NOT*** indicate voltage then place the Start-Run-Stop switch back to the Run position until the voltmeter indicates voltage then release it.

**NOTE:**

The engine must be above 600 RPM and speed switch S9-1 contacts must have closed. Also S7 (battleshort switch) must be OFF (Figure 1).

**Re-flashing generator exciter (MEP 12 generator):**

A MEP 12 generator has a field flashing circuit also. The only exception is that the generator has to be completely shutdown and restarted. The Run-Start-Stop cannot be placed back into the Run position to re-flash the exciter field. This is due to engine Speed Switch SS1 (Figure 1 & 2). Its contacts will **open** at 700 RPMS, instead of engine Speed Switch S9-1 **closing** at 610 RPMS on the other MEP generators.

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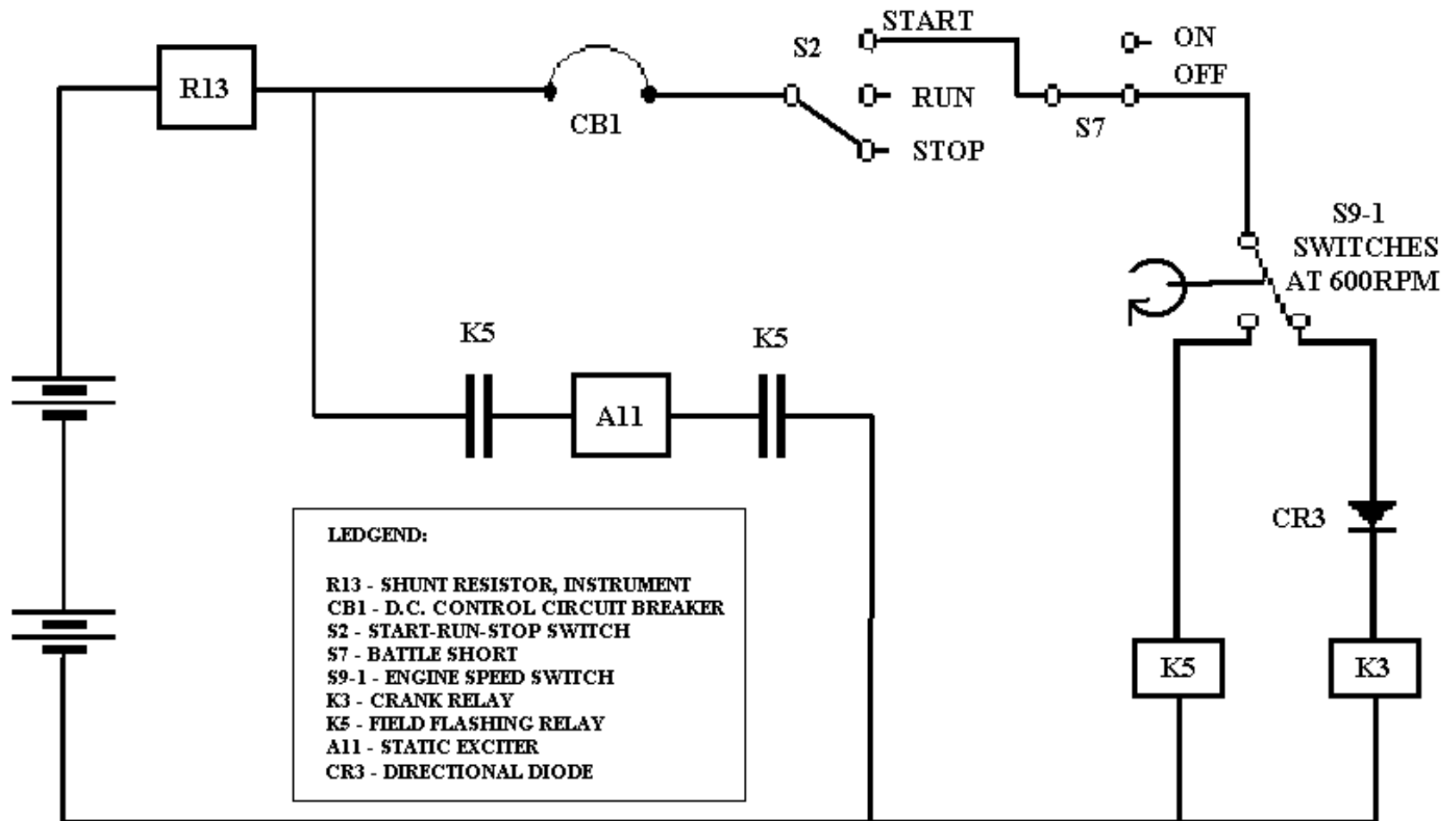


Figure 1, MEP 4-9 DC Diagram (Field Flashing Circuit)

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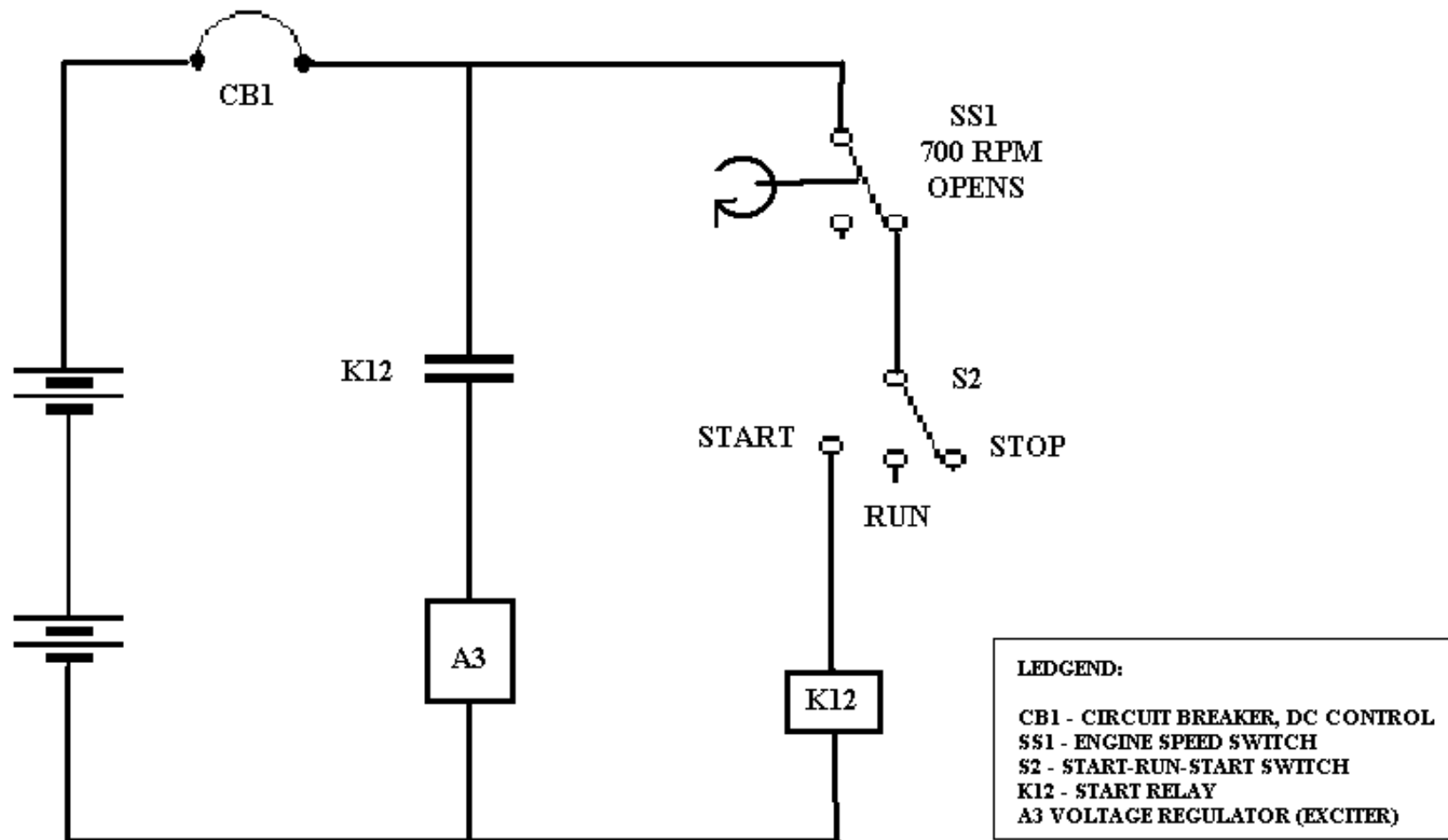


Figure 2, MEP 12 DC Diagram

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### Review Questions for Flash Exciter Field

Question	Answer
1. MEP generators <u>do not</u> have a self-excitation circuit.	a. True b. False
2. On a MEP generator which relay will flash the field of the exciter?	a. K4 b. K5 c. K6 d. K7
3. Which of the following should be done if a MEP 5 generator will not build up voltage after starting?	a. Place the Run-Start-Stop switch to the Automatic position. b. Place the Run-Start-Stop switch to the Run position. c. Place the Run-Start-Stop switch to the Start position. d. Place the Run-Start-Stop switch to the Stop position.
4. The MEP 12 generator must be shut down and restarted to re-flash the exciter field.	a. True b. False
5. A technician should <u>Never</u> hook-up a battery directly to the exciter in order to flash the exciter field.	c. True d. False

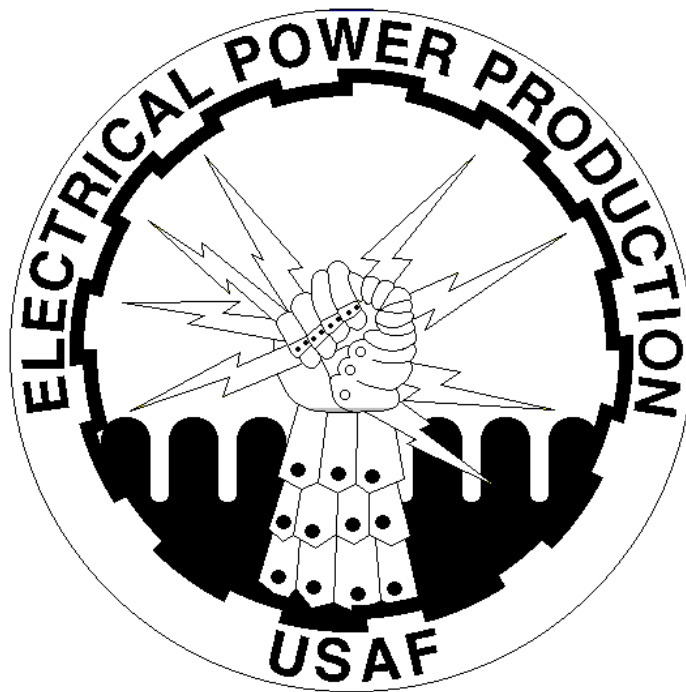
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### FLASH EXCITER FIELDS

Performance Checklist		
Step	Yes	No
1. Did the trainee successfully flash the exciter field during start-up on a MEP generator?		
2. Did the trainee re-flash the generator exciter field after start-up on a MEP generator?		

**FEEDBACK:** Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.

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## ALTERNATORS, EXCITERS, AND ELECTRIC MOTOR GENERATORS

**MODULE 22**

**AFQTP UNIT 8**

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**TROUBLESHOOT (22.8.)**

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## TROUBLESHOOT

### *Task Training Guide*

<b>CFETP Reference Number:</b>	22.8., Troubleshoot
<b>Training References:</b>	<ul style="list-style-type: none"> <li>35C2 series Technical Order</li> </ul>
<b>Prerequisites</b>	<ul style="list-style-type: none"> <li>Possess as a minimum a, 3E032 AFSC</li> </ul>
<b>Equipment/Tools Required:</b>	<ul style="list-style-type: none"> <li>Multimeter (Digital with diode check capability) with test leads</li> <li>DC variable power supply (minimum output voltage 20 volts, minimum output current 5 amps) with test leads</li> <li>Clamp-on DC ammeter (NOT AC)</li> <li>Megger with test leads</li> <li>Hearing protection</li> <li>Eye protection</li> <li>Standard Power Production tool box</li> </ul>
<b>Learning Objective:</b>	<ul style="list-style-type: none"> <li>Troubleshoot alternators, exciters, &amp; motor generators.</li> </ul>
<b>Samples of Behavior:</b>	<ul style="list-style-type: none"> <li>Trainee should successfully troubleshoot alternators, exciters, &amp; motor generators.</li> </ul>
<b>Notes:</b>	
<ul style="list-style-type: none"> <li>Any safety violation is an automatic failure.</li> </ul>	

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## TROUBLESHOOT

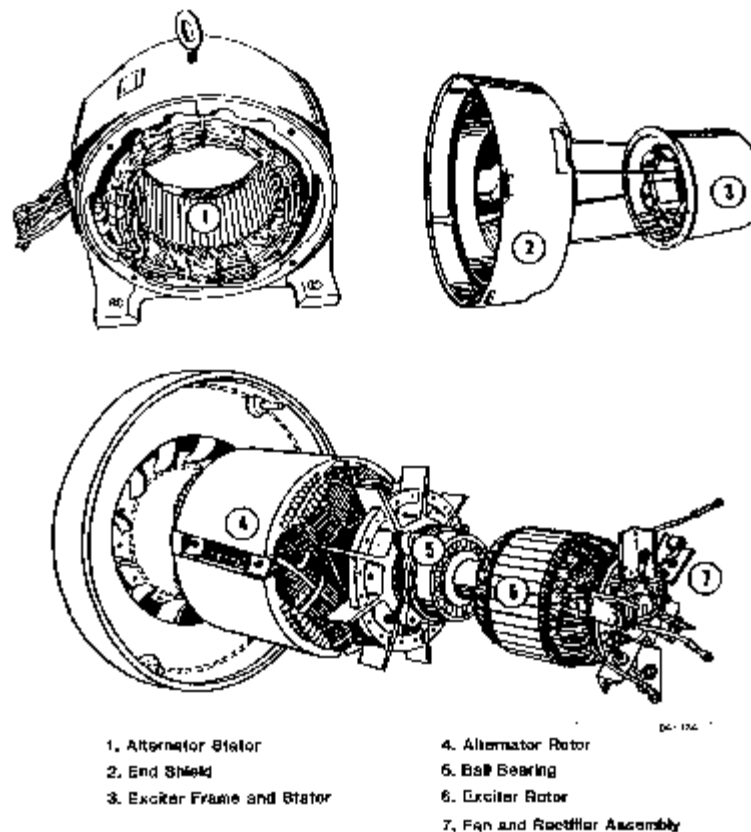
### Background:

**Alternators.** They are used to produce electrical power to meet load demands. Alternators are designed for use in electrical generating systems and consist of three main assemblies: the rotor and shaft assembly, the stator and frame assembly, and the collector or rectifier assembly.

**Exciters.** They are used to produce DC voltage by means of electromagnetic induction. Exciters are basically, three phase AC alternators and are self-excited. The power from an exciter is rectified into DC power and used as a means of controlling the alternator's output voltage. There are two types of exciters, the brush type and brushless. The brush type changes AC power to DC power by use of a commutator and brushes. The brushless type uses solid state (diode) devices to rectify AC power to DC power and is the most prevalent system used today.

**NOTE:**

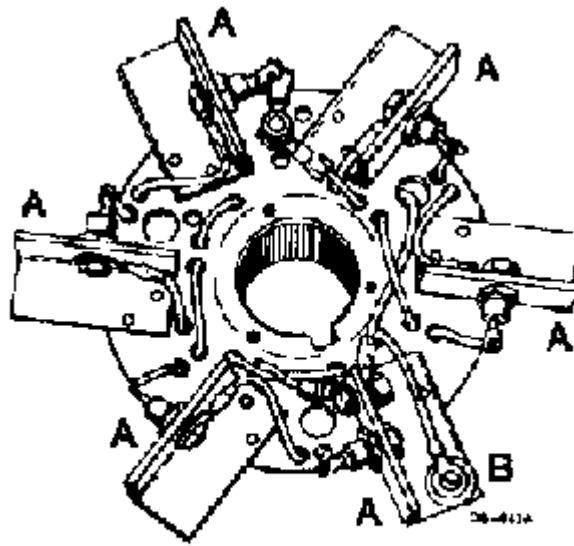
All MEP generators are of the brushless type.



**NOTE:** Items 1, 2, and 3 are not of the same size as items 4, 5, 6, and 7.

**Figure 1, Brushless Generator Components**

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**SILICON DIODES-A  
SURGE SUPPRESSOR-B**

Figure 2, Rectifier Assembly



Figure 3, Fluke 77 Multimeter

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**Figure 4, Hewlett Packard Dual Variable DC Power Supply**



**Figure 5, Meg-Check Meter**

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### **Symptoms and Isolation of Malfunctions.**

Either low output voltage or no voltage output usually indicates a malfunction of the generator.

### **To isolate the malfunction proceed as follows:**

**Generator Run-Up Test.** Step 1: Disconnect generator set air intake doors, below control cubicle.



**Figure 6, Removal of Louver (MEP-006)**

#### **SAFETY:**

**MAKE SURE JEWELRY IS REMOVED. GENERATORS SHOULD BE TURNED OFF AND DC BREAKER PULLED OUT.**

Step 2: Disconnect generator set air inlet louver and screen assembly

Step 3: Remove wires to the exciter field terminals.

#### **SAFETY:**

**ALWAYS CHECK A CIRCUIT WITH A VOLTMETER BEFORE REMOVING LEADS. THERE MAY BE VOLTAGE FROM CAPACITORS OR OTHER AUXILIARY POWER SUPPLIES IN THE CIRCUIT.**

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- MEP 6: Disconnect the top two leads on terminals 15 and 16 of TB16 (located on the current transformer mount plate) and tag them 15 and 16.
- MEP 7, 9: Disconnect electrical connector P61 from right side of generator endbell.
- Connect a variable voltage DC power supply.

**SAFETY:**

**DC POWER SUPPLY SHOULD BE TURNED OFF AND SET TO ZERO VOLTS DC.**

- **MEP 6.**
  - (+) terminal to the positive side (wire that was connected to terminal 15) of the exciter.
  - (–) terminal to the negative side (wire that was connected to terminal 16) of the exciter.



**Figure 7, Connection of DC Power Supply to (MEP 6)**

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- **MEP 7, 9.**
  - (+) Terminal to the positive side (J61 pin C) of the exciter.
  - (–) Terminal to the negative side (J61 pin B) of the exciter.
  - Clamp-on the DC ammeter to one of the leads, of the DC variable power supplies.
  - Start the generator set and operate the engine to 1800 RPM.
  - Adjust the variable DC voltage supply until normal generator output voltage is obtained (120 / 208).

**SAFETY:**

**THE CLAMP-ON AMMETER USED MUST BE CAPABLE OF BEING USED IN A DC CIRCUIT. NOT ALL CLAMP-ON METERS ARE RATED FOR BOTH AC AND DC.**

**SAFETY:**

**PERFORM ALL PREOPERATIONAL INSPECTIONS AND WEAR PROPER SAFETY EQUIPMENT WHILE THE GENERATOR IS IN OPERATION. MAKE SURE THAT ALL TEST EQUIPMENT AND LEADS ARE AWAY FROM ROTATING EQUIPMENT AND OTHER VOLTAGE SOURCES. TAPE THE ENDS OF THE TEST LEADS IF NEEDED. DISCONNECT ALL LOADS FROM THE OUTPUT TERMINALS OF THE GENERATOR BEFORE OPERATION.**

**NOTE:**

By applying a small amount of DC voltage from DC power supply the voltage and frequency meter will start operating. Increase frequency to 60 hertz. This will equal 1800 rpms.

**SAFETY:**

**RAISE THE VOLTAGE ON THE DC POWER SUPPLY SLOWLY TO RATED VOLTAGE OR DAMAGE TO THE EXCITER MIGHT RESULT.**

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**Figure 8, Adjusting The Variable DC Voltage On A (MEP 6)**

- DC clamp-on ammeter should indicate a amperage between 1 and 1.75 amps.
- If the DC ammeter indicates correct input exciter current to obtain rated voltage then the problem lies in the excitation system (voltage regulator).
- If the DC ammeter indicates incorrect input exciter current to obtain rated voltage in steps 6 thru 8 above, the generator has failed. The following steps are presented to enable isolation of the fault within the generator.

**NOTE:**

High current may indicate a short in the exciter stator windings.  
No current may indicate open in the exciter stator windings.

**Exciter stator windings test.**

- Open test. Check resistance, with a wheatstone bridge or other suitable low resistance measuring device, between:

**NOTE:**

A digital multimeter such as the fluke 8060a, 87, or 77 will accomplish this measurement.

**SAFETY:**

**TEST CIRCUIT WITH A VOLTMETER BEFORE REMOVING OR TOUCHING ANYTHING ELECTRICAL.**

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- MEP 6: the two top wires from pins 15 and 16, field resistance should be between 2.90 and 3.55 ohms +/- 10 percent.
- MEP 7 & 9: J61 pins B and C, field resistance should be 1.23 ohms +/- 10 percent.
- A high resistance will indicate a open in the stator windings.



**Figure 9, Stator Resistance Test with Multimeter (MEP6)**

**Short To Frame and Insulation Resistance Test.**

- Check resistance with a Megger between:

**SAFETY:**

**A MEGGER WILL PRODUCE 500 VDC AND CAUTION SHOULD BE USED WHEN USING THIS PIECE OF TEST EQUIPMENT. DO NOT TRY TO HOLD ON TO THE LEADS WHEN IN TEST, SEVER ELECTROCUTION MAY OCCUR.**

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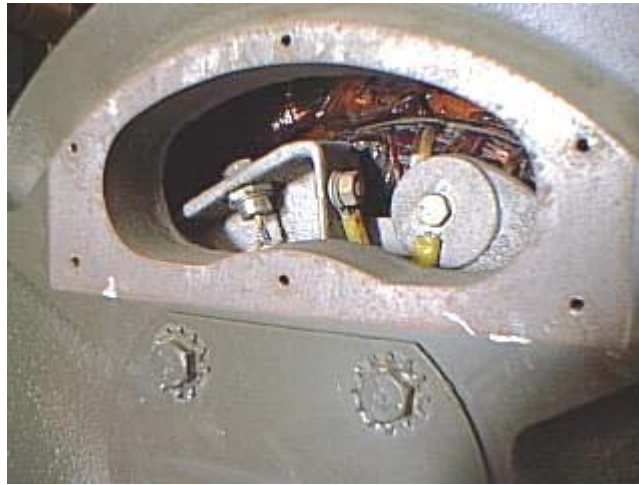
**Figure 10, Stator Insulation Test with Megger (MEP6)**

- MEP 6: Connect Red lead of megger to the top wires from pins 15 & 16, and the black lead of megger to the generator frame.
- MEP 7 & 9: Electrical bond (jumper) J61 pins B & C and connect to Red lead of megger, also connect the Black lead of the megger to the generator frame.
- The resistance measured should be a minimum of 1 megaohm.
- If the resistance is lower than this a short or insulation breakdown between the frame and exciter stator windings exists.

#### **Rectifier diode test.**

- Remove cover plate and gasket from generator endbell to expose the rectifier diodes.

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**Figure 11, Rectifier Diodes (MEP 6)**

- Remove the nuts to each diode and slide it off of the rectifier assemble one at a time and test. Make sure that the nut side of the diode is not touching anything when testing.



**Figure 12, Removal of Diode Nuts (MEP 6)**

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### Testing Diodes.

**SAFETY:**

**TEST CIRCUIT WITH A VOLTMETER BEFORE REMOVING OR TOUCHING ANYTHING ELECTRICAL.**

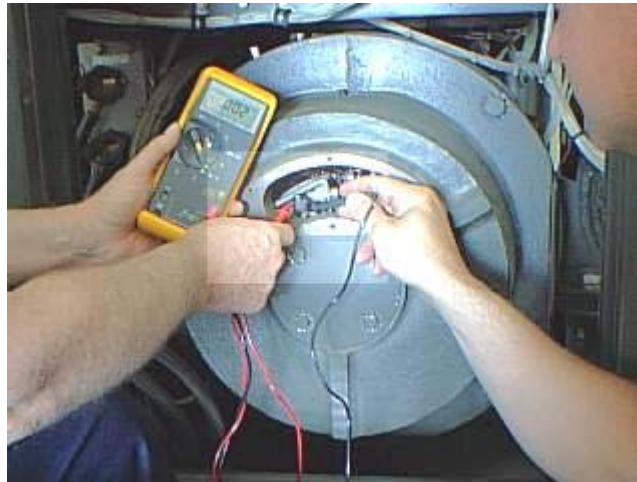
#### Digital Multimeter.

- Place the meter in the diode test function.
- Place the Black lead on the diodes cathode (end where the nut was on).
- Place the Red lead on the diodes anode (lead with the wire on it).
- The reading should be .\*\*\*\* .

**NOTE:**

Do not place the digital multimeter in the ohm scale to test diodes. The test current on a digital multimeter is not great enough to bias a semiconductor device. This will lead to a false reading. Remember they did not put the function on the meter for no reason.

The .\*\*\*\* Reading above means that the \* is of some numerical value, Typically between .7 & .3.



**Figure 13, Testing Diodes with Multimeter (MEP 6)**

- Place the Red lead on the diodes cathode (end where the nut was on).
- Place the Black lead on the diodes anode (lead with the wire on it).
- The reading should be OL .
- If these readings where not correct replace the diode.

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**Analog Multimeter.**

- Place the meter in the ohms Rx1 test function.
- Place the Black lead on the diodes cathode (end where the nut was on).
- Place the Red lead on the diodes anode (lead with the wire on it).
- The reading should be between **20 to 40 ohms**.
- Place the Red lead on the diodes cathode (end where the nut was on).
- Place the Black lead on the diode anode (lead with the wire on it).
- The reading should have **infinite** resistance.
- If these readings where not correct replace the diode.

**NOTE:**

Only use the r x1 setting other settings may not have a test current high enough to bias a diode. This may cause a false reading.

**Alternator Stator Windings Test.**

- Remove plastic shield from reconnection panel.
- Tag and disconnect the twelve stator leads at the voltage reconnection panel.

**SAFETY:**

**TEST CIRCUIT WITH A VOLTMETER BEFORE REMOVING OR TOUCHING ANYTHING ELECTRICAL.**

**Open Test.**

- Check resistance, using a Kelvin bridge or other suitable low resistance-measuring device between:

**NOTE:**

A digital multimeter such as the fluke 8060a, 87, or 77 will accomplish this measurement

- Check resistance between generator leads T1-T4, T2-T5, T3-T6, T7-T10, T8-T11, and T9-T12,. This will measure each of the six-stator windings.
- Resistance should be:
- MEP 6: 0.0141 to 0.0173 ohms +/- 10 percent
- MEP 7: 0.00974 ohms +/- 10 percent
- MEP 9: 0.00455 ohms +/- 10 percent
- A high resistance will indicate a open in the stator windings.

**Short To Frame and Insulation Resistance Test.**

- Check resistance with a Megger between:
- Connect all stator leads together and connect to the Red lead of megger.
- Connect the Black lead of megger to the generator frame.
- The resistance measured should be a minimum of 1 megaohm.

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- If the resistance is lower than this a short or insulation breakdown between the frame and alternator stator windings exists.

**SAFETY:**

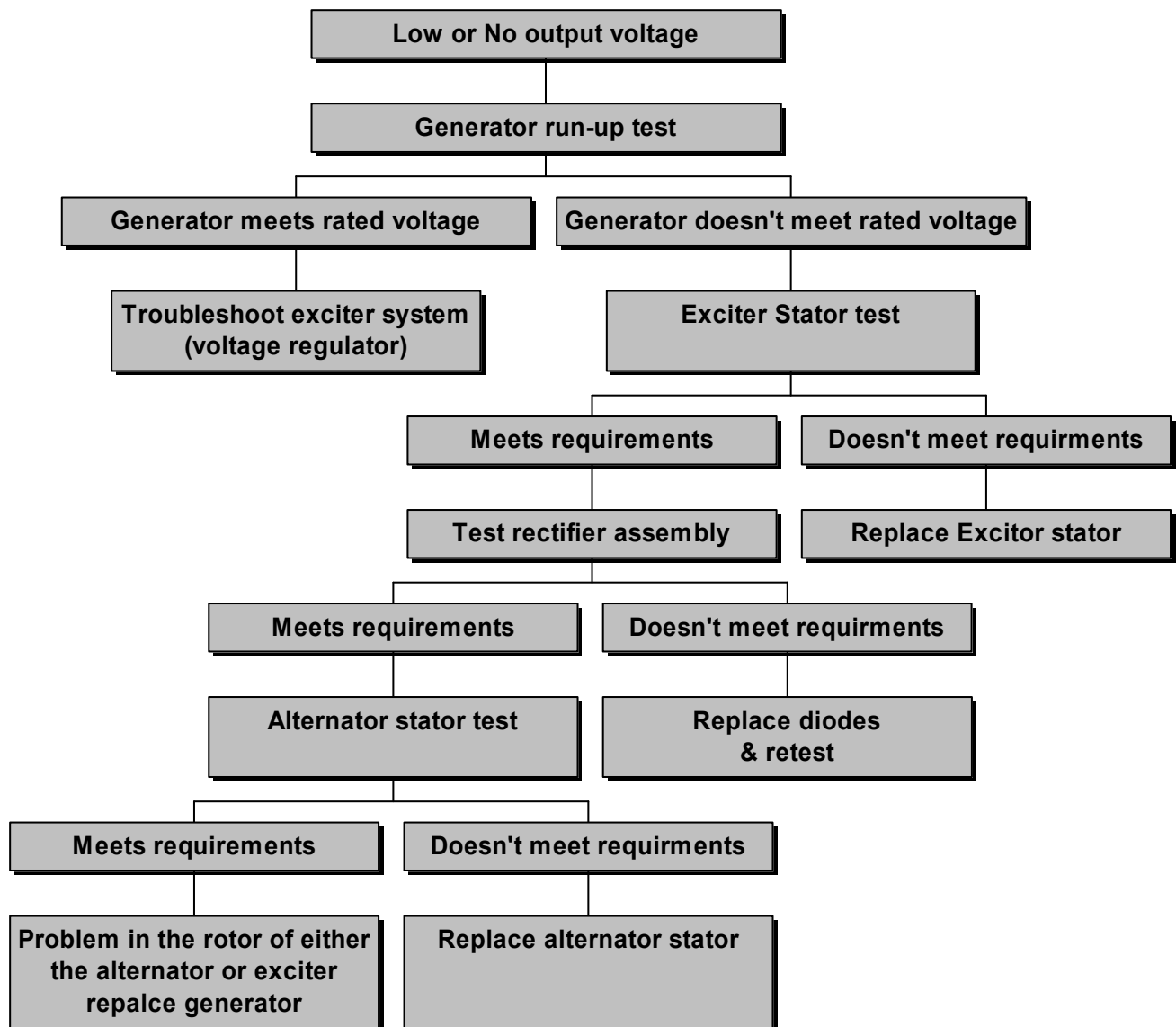
**A MEGGER WILL PRODUCE 500 VDC AND CAUTION SUCH BE USED WHEN USING THIS PIECE OF TEST EQUIPMNET. DO NOT TRY TO HOLD ON TO THE LEADS WHEN IN TEST, SEVER ELECTROCUTION MAY OCCUR.**

If the following checks above are met, then the problem lies in the rotor of the exciter or alternator and must be replace. If the problem was in the stator of the alternator or exciter then they must be replaced. If the only problem was the rectifier diodes then replace them, reassemble and restart the generator.

Remember the main purpose of troubleshooting is to narrow down as much as possible the probable cause. Even though these procedures might be extensive they will diffidently identify the cause without undue expense. The cost of a new alternator or exciter will be in the thousands of dollars, this is far more expensive then the comparative cost of a couple of hours of good troubleshooting for a less expensive item.

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### ***Alternator & Exciter Faults***



**Chart 1, Alternator & Exciter Troubleshooting Chart**

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## Review Questions for Troubleshoot

Question	Answer
1. The brushless type generator uses a _____ to rectify AC power to DC power.	a. Silicon Controlled Rectifier b. Commutator c. Transistor d. Diode
2. What is the purpose of the variable DC power supply?	a. To apply a current to the exciter stator windings b. To apply a current to the voltage regulator c. To apply a current to the exciter rotor d. To apply a current to the alternator stator windings
3. If the DC ammeter reads zero amps during the run-up test, what is the possible cause?	a. Open in the exciter rotor windings b. Open in the alternator rotor windings c. Open in the exciter stator windings d. Open in the alternator stator windings
4. If the reading on the megger is 10 kilo ohms during the exciter stator test, what is the possible cause?	a. Open in the exciter stator windings b. Open in the alternator stator windings c. Short in the alternator stator windings d. Short in the exciter stator windings
5. When testing the rectifier section, which of the following readings would indicate a good reading?	a. OL in direction and a .**** in the other b. .**** in both directions c. OL in both directions d. None of the above

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## TROUBLESHOOT

Performance Checklist		
Step	Yes	No
1. Followed safety procedures		
2. Used test equipment properly		
3. Performed different techniques in troubleshooting		
4. Demonstrated knowledge of the devices being troubleshoot?		

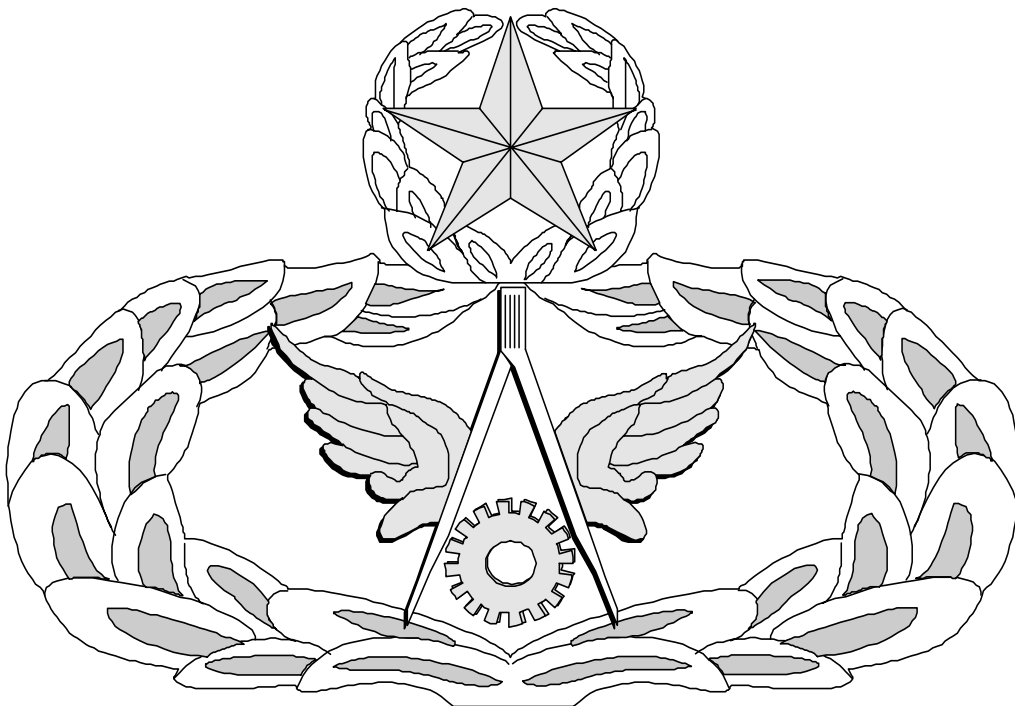
**FEEDBACK:** Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.

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# **Air Force Civil Engineer**

## **QUALIFICATION TRAINING PACKAGE (QTP)**

### **ANSWER KEY**



**For**

## **Power Production Systems**

**(3E0X2)**

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**FLASH EXCITER FIELD****(3E0X2-22.4.)**

<b>Question</b>	<b>Answer</b>
1. MEP generators <u>do not</u> have a self-excitation circuit.	b. False
2. On a MEP generator which relay will flash the field of the exciter?	b. K5
3. Which of the following should be done if a MEP 5 generator will not build up voltage after starting?	c. Place the Run-Start-Stop switch to the Start position
4. The MEP 12 generator must be shut down and restarted to re-flash the exciter field.	a. True
5. A technician should <u>Never</u> hook-up a battery directly to the exciter in order to flash the exciter field.	a. True

**TROUBLESHOOT****(3E0X2-22.8.)**

<b>Question</b>	<b>Answer</b>
1. The brushless type generator uses a _____ to rectify AC power to DC power.	d. Diode
2. What is the purpose of the variable DC power supply?	a. To apply a current to the exciter stator windings
3. If the DC ammeter reads zero amps during the run-up test, what is the possible cause?	a. Open in the exciter stator windings
4. If the reading on the megger is 10 kilo ohms during the exciter stator test, what is the possible cause?	d. Short in the exciter stator windings
5. When testing the rectifier section, which of the following readings would indicate a good reading?	a. OL in direction and a .**** in the other

**Notice.** This AFQTP is NOT intended to replace the applicable technical references nor is it intended to replace hands-on training if equipment is available. It is to be used in conjunction with these for training purposes only.